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M-B boundary age constrained by high-precision U-Pb zircon dating of a widespread tephra in a sedimentary sequence

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Geomagnetic polarity reversals, including the Matuyama-Brunhes boundary (MBB), are critical markers in age calibrating sedimentary sequences with volcanic rocks. Most age determinations for the MBB use marine astronomically-tuned benthic and planktonic foraminiferal oxygen isotope records to date the mid-point in the transition of the virtual geomagnetic pole (VGP). During the MBB and other reversals, the Earth's geomagnetic field intensity dropped significantly, resulting in the increased production of cosmogenic radionuclides, including ^{10}Be, in the upper atmosphere. Hence, the MBB has also been recognized as a positive spike in the ^{10}Be flux recorded in marine sediments and an Antarctic ice core.

The MBB has a frequently cited age of 780 ka, which derives from astronomically-tuned benthic and planktonic oxygen isotope records from the eastern equatorial Pacific. This marine astronomically-dated MBB age is supported by ^{40}Ar/^{39}Ar ages of Maui lavas at 781-783 ka, revised by the recent reference age of Fish Canyon Tuff sanidine (FCTs) standards. However, an understanding of post-depositional remanent magnetization (PDRM) processes shows that lock-in of the geomagnetic signal occurs below the sediment?water interface in marine sediments, which then yields ages for geomagnetic events that are too old. Because this age offset is influenced by sedimentation rate, those records with higher sedimentation rates should minimize the PDRM lock-in problem. In fact, younger astrochronological MBB ages of 772-773 ka have been reported from high sedimentation rate records. These MBB ages are consistent with records of cosmogenic nuclides in marine sediments and an Antarctic ice core, although they are not supported by radiometric timescales.

Here, we present a high-precision U-Pb zircon age of 772.7 $\pm$ 7.2 ka from a marine-deposited tephra just below the MBB in a forearc basin in Japan. Because the U-series dating is relatively free from issues about standardization and decay constants, this U-Pb zircon age coupled with a newly obtained oxygen isotope chronology yields a highly accurate MBB age of 770.2 $\pm$ 7.3 ka. Our MBB age is consistent with those based on the latest orbital-tuned marine sediments. We provide the first direct comparison between orbital tuning, U-Pb dating, and magnetostratigraphy for the MBB, fulfilling a key requirement for calibrating the geological timescales.